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NAVORD REPORT 2124

INVESTIGATION OF DESIGN FACTORS FOR STEEL GUN PRIMER TUBES

11 MAY 1953

U. S. NAVAL ORDNANCE LABORATORY

WHITE OAK, MARYLAND

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SECURITY INFORMATION

INVESTIGATION OF DESIGN FACTORS FOR STEEL GUN PRIMER TUBES

Prepared by:

L. F. Gowen

ABSTRACT: Ruptured primer tubes can cause considerable damage to guns. For this reason the Naval Ordnance Laboratory has determined the pressures required to rupture gun primer tubes of various designs. Design parameters investigated included the unvented length, the vent hole diameter, shape of the vent hole, the wall thickness and inside diameter of the primer tube and the amount of powder charge. The effect of variations in these design parameters on the pressure developed inside the primer tube also was determined.

The results of the investigation indicate that primer tubes may rupture at pressures as low as 17,000 psi or as high as 53,000 psi, depending on the primer design. Primer tubes with either short unvented length or small vent hole diameters maintain peak pressures longer and rupture at lower pressures than tubes with longer unvented lengths or large vent hole diameters. The rupturing pressure increases with the tube wall thickness and decreases as the inside diameter of the tube increases. The peak pressure developed inside a primer tube is affected by the unvented length. The peak pressure is not significantly affected by the amount of unvented length when a partial charge, such as the tube 1/3 or 1/2 full, is used. Pressures simultaneously recorded at various positions in the primer tube indicate that a pressure gradient exists in the tube, the maximum pressure occurring in the vicinity of the first vent holes.

Firing tests on tubes with transverse slots in place of round vent holes showed that for the same hole area the slotted tubes failed at lower initial pressures, presumably due to lateral forces exerted on the tube during firing.

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

NAVORD Report 2124 11 May 1953

This is a final report on the task to investigate the design factors for steel primer tubes. NOLM 10599 was an interim report on this task. This study was authorized by the Bureau of Ordnance under Task NOL-Re2a-184-1. The information presented may be useful to activities interested in primer tube design.

EDWARD L. WOODYARD
Captain, USN
Commander

D. E. Sanford

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By direction

CONTENTS

REFERENCES

a. BuOrd ltr NP51 (Re2a-184-1) of 20 Oct 1948 to NOL.

b. NOLM 10599 "Investigation of the Design Factors for Steel Primer Tubes", L. F. Gowen.

c. NOLM 10713 "Two-channel Osillo-recorder, Design and Operating Details", J. N. Ayres.

ILLUSTRATIONS

INVESTIGATION OF DESIGN FACTORS FOR STEEL PRIMER TUBES

INTRODUCTION

1. Primer tubes have occasionally ruptured in gun firing tests at the Naval Proving Ground, Dahlgren, Va. Ruptured primer tubes can cause severe damage to guns. In order to obtain basic information that might lead to the elimination of tube bursts in guns, the Bureau of Ordnance established a task at the Laboratory to investigate design factors for steel primer tubes. The primary purpose of the Laboratory's investigation was to attempt to relate the pressure required to burst a primer tube to the primer tube design. Reference (b) is an interim report on the task which outlines the program plan, describes the instrumentation and procedure used and presents the data available. This is a closing report on the task.

2. This report presents data and discusses the results obtained in the four phases investigated:

Phase 1 – Tube burst studies in which the unvented length, the vent hole diameter, wall thickness and inside diameter were varied.

Phase 2 – Studies to determine the effect of reduced charges on internal tube pressures.

Phase 3 – Studies to determine whether or not pressure gradients exist inside the primer tube during the burning of the powder charge.

Phase 4 – Studies to determine the effect of vent hole shape on the pressure required to rupture primer tubes.

Instrumentation and Procedure

3. Since the interim report (reference (b)) was published, the instrumentation has been modified. The single channel cathode ray oscilloscope was replaced by a dual channel cathode ray oscilloscope. This oscilloscope makes it possible to make two pressure records simultaneously. The new instrumentation is described in detail in reference (c).

4. In the tube burst studies, tubes of each design were fired with powder charges that gave increasingly higher peak pressures until at least three tubes ruptured. Tubes that showed no damage or distortion after firing were re-used. Several shots were made with each powder charge to more accurately determine the pressures being developed in the primer tube. The number of shots made is indicated in the accompanying tables. The primer tubes used in all phases of this study were essentially modifications of the Mk 39 primer tube which is shown in plate 1. The Mk 39 primer tube is fabricated from An-T-15 seamless steel tubing which has a tensile strength of 95,000 psi. The tube has a length of 20.25 inches, an inside diameter of .580 inches, a minimum wall thickness of .085 inches, and an unvented length of 3.75 inches.

Tube Burst Studies

5. The results obtained in the tube burst studies for primer tubes having 9/32 of an inch diameter vent holes and unvented lengths of 2, 5, 7 and 9 inches were reported in reference (b). Results obtained in this study for tubes having 3/32, 5/32 and 7/32 of an inch diameter vent holes and unvented lengths of 2, 5, 7 and 9 inches are presented in Table 1. The tubes used in these tests were identical to the Mk 39 primer tubes except for variations in the vent hole diameters and the unvented length. Peak pressures plotted as a function of the unvented length for various primer charges based on the data in Table 1 are shown in plates 2, 3 and 4. The rupturing pressures and other related data for each tube design are presented in Table 2.

6. Data in Table 2 indicate that low average rupturing pressures were obtained for tubes with 2 inches of unvented length and 3/32 or 5/32 of an inch diameter vent holes, and also for tubes with 5 inches unvented length and 3/32 of an inch diameter vent holes. The pressure-time curves may present an explanation for these anomalies. The curves show that the peak pressure in the tubes which ruptured at low pressures was maintained considerably longer than the peak pressure in the tubes which ruptured at higher pressures. This is shown in plate 5, which presents reproductions of typical pressure-time curves obtained when firing the above primers.

7. Studies to determine the relation between wall thickness and rupturing pressure were conducted. The tubes used in these studies were identical in design to the Mk 39 service primer tube with the exception that the wall thickness was varied, the inside diameter of the tube being held constant. Tube wall thicknesses of .065, .095, .120 and .156 inches were investigated.

The peak pressures recorded on these shots and other related data are presented in Table 3. Rupturing pressures plotted as a function of the wall thickness based on the data in Table 4 are shown in plate 6. As shown in plate 6, the rupturing pressure increases with the wall thickness of the tube in a non-linear manner. A considerable number of the .156 tubes bulged at pressures below the average rupturing pressure. In some cases abnormally high pressures were obtained in the ".156 tubes, much higher than those obtained with the same charge in the thinner walled tubes.

8. Studies to determine the relation between the inside diameter of primer tubes and the rupturing pressure were conducted. The tubes used in this study were identical in design to the Mk 39 service primer tubes with the exception that the inside diameter was varied, which, of course, controls the maximum amount of primer charge used. The wall thickness was held constant. The peak pressures recorded for these shots and other related data are recorded in Table 5. Rupturing pressures plotted as a function of the inside diameter of the tubes based on the data in Table 6 are shown in plate 7. It will be noted that the rupturing pressure decreases in a non-linear manner as the inside diameter of the tube increases. The total inside area of the larger tube is greater than that of the smaller tube and is consequently subjected to larger total forces.

Partial Charge Studies

9. A series of shots were made to determine the relation between unvented length, amount of primer charge and the peak pressure developed in the tube. The Mk 39 and Mk 46 (XCM 11) primer tubes were used in these studies. The Mk 46 primer tube is identical to the Mk 39 primer tube with the exception that the tube length is 15.75 inches and the unvented length is 6.75 inches (compared to 20.25 inches and 3.75 inches for the Mk 39). In these tests the peak pressure was determined for Mk 39 primer tubes with a full service charge of 87 grams of cannon powder and with a half charge of 43.5 grams of cannon powder. Peak pressures were also determined for Mk 46 primer tubes containing the service charge of 26 grams of cannon powder (tube about 2/5 full) and a full charge of 70 grams of cannon powder. Modified Mk 46 primer tubes with unvented lengths of 3.75 and 9.75 inches were fired with primer charges of 26 and 70 grams of cannon powder. The results of these tests are shown in Table 7. Within the limitations of the test, the data in Table 7 indicate that: (a) the increase in peak pressure with increase in powder charge was insignificant for tubes with an unvented length of 3.75 inches; (b) the peak pressure increased greatly with increased powder charges for unvented lengths of 6.75 and 9.75 inches; (c) the peak pressure

was only slightly affected by the amount of unvented length when a reduced charge was used; (d) the peak pressure was greatly affected by the amount of unvented length when a full powder charge was used.

Pressure Variation in Primer Tubes

10. A study was conducted to determine the difference in peak pressure recorded at the base of the primer tube and at selected distances above the base. A heavy walled tube (plate 8) equipped to accommodate pressure gauges at five positions along the tube was used in this investigation. The tube that contained 90 grams of cannon powder was 21 inches long and had an unvented length of 9 inches. The inside diameter of the tube and the vent hole diameter and spacing were the same as used in the primer, Mk 39. One pressure gauge was placed at the base of the tube (2.5 inches above the stock) and a second gauge was placed at one of the other four gauge positions (6, 10.5, 15, 19.5 inches from the stock). In order to determine the relation between peak pressure and the loss of powder which is ejected from the end of the tube, the series of shots was repeated with a steel closing cap replacing the conventional paper cap on the end of the tube. The results of these tests are recorded in Table 8 and are shown graphically in plate 9. The results indicate that the maximum pressure developed in the tube occurred above the base position. It is interesting to note that the pressure as recorded at the base of the tube rises relatively slowly (1.0 ms from start of rise to peak) as compared to the pressures recorded at the other position (.1 ms from start of rise to peak). Sample curves are shown in plate 10.

Vent Hole Design

11. A consideration of the effect of vent hole shape on the pressure that a primer extension tube will stand without bursting, indicates that a slot with its long axis in a plane perpendicular to the axis of the tube would weaken the tube less than a round hole of equal area. The following three tube designs were test fired to determine whether there is any strength advantage in using slot-like vent holes in place of the round vent holes.

(a) Mk 39 type primer tubes with 3/16" round holes in place of the 7/32" holes normally used.

(b) Mk 39 type primer tubes with slots in place of round holes. The slots had the same area as the 3/16" holes. They had a rectangular area ".062 wide and ".394 long (measured along the outside circumference of the tube) with a semicircular area ".062 in diameter at each end.

(c) Mk 39 type primer tubes without vent holes.

The results presented in Table 9 show that the slotted tube ruptured at lower pressures than tubes with round vent holes or tubes with no vent holes. It was noted that the slotted tubes tended to bend at the slots, which may have caused the tubes to fail at lower pressures.

12. Although the primary purpose of the studies was to determine tube burst pressure, the information obtained in the investigation may be helpful in the primer design. Recent tests at Dahlgren indicate that there is some correlation between the pressure developed in the primer tube and the internal ballistics of a gun. Very preliminary data indicate that more desirable gun ballistics are obtained with primers that produce low pressures. This requires the accumulation of more data for proof and is being further investigated in connection with other phases of this same task.

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TABLE I

PEAK PRESSURE AND OTHER DATA ON PRIMER TUBES WITH VARIOUS VENT HOLE DIAMETERS AND UNVENTED LENGTHS

Vent Hole Diameter (inches)	Unvented Length (inches)	Powder Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
3/32	2	Cannon 87 grams	13,000 13,600 13,300	13,300	300	2.26	
3/32	5	Cannon 87 grams	15,400 19,000) * 17,700) 17,700) * 16,500)	17,260	1,744	10.1	
3/32	7	Cannon 87 grams	20,200 19,800 19,900	19,966	208	1.04	
3/32	9	Cannon 87 grams	21,100 21,900 19,300	20,710	1,133	6.44	
3/32	2	3FG+4%pp** 80 grams	13,600) * 15,200) 13,200) * 12,400) 13,000	13,480	1,055	7.83	

* Indicates that two pressure measurements were simultaneously recorded.

** Pistol Powder SR4990.

TABLE I (continued)

Vent Hole Diameter (inches)	Unvented Length (inches)	Powder Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
3/32	5	3FG+4%pp 80 grams	15,800 19,700 18,000	17,833	1,336	7.49	Rupt.
3/32	7	3FG+4%pp 80 grams	19,000 22,000) * 20,000) 18,100) * 17,500)	19,320	1,519	7.86	
3/32	9	3FG+4%pp 80 grams	23,000) * 21,500) 21,000) * 18,000) 22,200) * 24,300)	21,667	2,141	9.88	
3/32	2	3FG+8%pp 76 grams	19,600 21,900) * 18,400) 17,700) * 18,700) 19,100) * 21,800) 17,700) * 16,700)	19,067	1,804	9.46	Rupt. Rupt. Rupt. Rupt. Rupt.

TABLE I (continued)

Vent Hole Diameter (inches)	Unvented Length (inches)	Powder Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
3/32	5	3FG+8%pp 76 grams	19,000) 20,100)* 21,600) 21,200)* 22,500) 24,500)*	21,483	1,914	8.91	Rupt. Rupt.
3/32	7	3FG+8%pp 76 grams	24,200) 25,000)* 24,800) 22,700)* 25,800) 25,700)*	24,700	1,145	4.64	Rupt.
3/32	9	3FG+8%pp 76 grams	23,800) 23,800)* 25,600) 25,500)* 26,300) 25,600)*	25,100	1,047	4.17	 Rupt.
3/32	7	3FG+12%pp 72 grams	29,400 34,500 34,500	32,800	2,944	8.97	Rupt. Rupt. Rupt.

TABLE I (continued)

Vent Hole Diameter (inches)	Unvented Length (inches)	Powder Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
3/32	9	3FG+12%pp 72 grams	32,300 30,200)* 27,500) 33,700	30,750	2,472	8.04	Rupt. Rupt. Rupt.
5/32	2	Cannon 87 grams	9,900 7,800 8,900	8,867	1,054	11.9	
5/32	5	Cannon 87 grams	14,900 13,800 14,500	14,400	557	3.87	
5/32	7	Cannon 87 grams	20,100 16,500 20,000)* 20,500)	19,275	1,862	9.66	
5/32	9	Cannon 87 grams	21,000 20,700 21,300	21,000	300	1.42	

TABLE I (continued)

Vent Hole Diameter (inches)	Unvented Length (inches)	Powder Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
5/32	5	3FG+4%pp 80 grams	17,700 20,400)* 21,200) 19,000)* 17,900)	19,240	1,533	7.97	
5/32	7	3FG+4%pp 80 grams	20,000)* 22,200) 20,900 22,000	21,275	1,023	4.81	
5/32	9	3FG+4%pp 80 grams	24,300)* 25,000) 27,100)* 28,000) 25,800	26,040	1,629	6.26	
5/32	2	3FG+8%pp 76 grams	15,800 12,700)* 12,200) 14,000)* 13,200)	13,580	1,408	10.4	

TABLE I (continued)

Vent Hole Diameter (inches)	Unvented Length (inches)	Powder Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
5/32	5	3FG+8%pp 76 grams	21,800)* 22,500) 19,800)* 18,000) 16,300	19,680	2,583	13.1	
5/32	7	3FG+8%pp 76 grams	22,200)* 20,100) 19,700)* 17,400) 20,600)* 24,700)	20,783	2,468	11.9	
5/32	9	3FG+8%pp 76 grams	28,400)* 27,400) 25,400)* 26,200) 25,300)* 27,000)	26,617	1,210	4.54	Rupt. Rupt.
5/32	2	3FG+12%pp 72 grams	18,100)* 18,200) 22,700)* 24,900) 18,200	20,420	2,273	11.1	Rupt.

TABLE I (continued)

Vent Hole Diameter (inches)	Unvented Length (inches)	Powder Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
5/32	5	3FG+12%pp 72 grams	27,500)* 29,700) 24,400)* 22,200) 32,800)* 30,800)	27,900	4,014	14.4	Rupt. Rupt. Rupt.
5/32	7	3FG+12%pp 72 grams	32,500)* 31,200) 32,400)* 27,700) 28,800)* 28,000)	30,100	2,196	9.30	Rupt. Rupt. Rupt.
5/32	9	3FG+12%pp 72 grams	34,900)* 34,500) 32,300 34,200)* 33,000)	33,780	1,089	3.22	Rupt. Rupt. Rupt.
5/32	2	3FG+16%pp 69 grams	25,900)* 24,000) 24,700)* 23,800) 22,900	24,260	1,118	4.61	Rupt. Rupt. Rupt.

TABLE I (continued)

Vent Hole Diameter (inches)	Unvented Length (inches)	Powder Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
7/32	2	Cannon 87 grams	7,400 5,500 8,400	7,100	1,473	20.7	
7/32	5	Cannon 87 grams	14,200 12,800)* 12,900) 11,000)* 11,800)	12,540	1,212	9.66	
7/32	7	Cannon 87 grams	18,800 15,800)* 15,500) 21,000)* 19,200)	18,060	2,353	13.0	
7/32	9	Cannon 87 grams	21,300 21,000)* 19,900) 22,900)* 23,100)	21,640	1,348	6.23	

TABLE I (continued)

Vent Hole Diameter (inches)	Unvented Length (inches)	Powder Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
7/32	9	3FG+4%pp 80 grams	19,400)* 21,400) 20,600)* 20,400) 20,300)* 21,300)	20,567	734	3.57	
7/32	2	3FG+8%pp 76 grams	15,700 15,900	15,800	141	0.89	
7/32	5	3FG+8%pp 76 grams	20,100 17,300 19,500)* 20,300)	19,300	1,376	7.13	
7/32	7	3FG+8%pp 76 grams	25,600)* 27,900) 23,500)* 22,700) 27,100	25,360	2,374	9.36	
7/32	9	3FG+8%pp 76 grams	24,100)* 22,500) 25,300)* 25,900) 25,700	24,700	1,414	9.62	

TABLE I (continued)

Vent Hole Diameter (inches)	Unvented Length (inches)	Powder Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
7/32	2	3FG+12%pp 72 grams	24,400)* 23,500) 20,600 21,400)* 21,800)	22,820	1,654	7.25	
7/32	5	3FG+12%pp 72 grams	26,500 26,000)* 26,200) 24,300	25,750	988	3.84	Rupt.
7/32	7	3FG+12%pp 72 grams	30,000)* 29,700) 24,500)* 25,200) 31,000	28,080	2,997	10.7	Rupt.
7/32	9	3FG+12%pp 72 grams	27,600 29,600)* 31,500) 29,700	29,600	1,594	5.39	Rupt. Rupt. Rupt.

TABLE I (continued)

Vent Hole Diameter (inches)	Unvented Length (inches)	Powder Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
7/32	2	3FG+16%pp 69 grams	27,400)				
			29,700)*				
			28,900)				
			27,300)*				
			30,600	28,780	1,437	4.99	Rupt.
7/32	5	3FG+16%pp 69 grams	26,700				Rupt.
			27,000)				Rupt.
			26,700)*				
			31,500)				Rupt.
			30,700)*	28,520	2,375	8.33	
7/32	7	3FG+16%pp 69 grams	33,700)				Rupt.
			31,000)*				
			32,000)				Rupt.
			31,000)*				
			28,900)				Rupt.
			32,700)*	31,550	1,660	5.26	
7/32	2	3FG+20%pp 66 grams	27,700)				Rupt.
			26,800)*				
			24,100)				Rupt.
			28,500)*				
			29,300)				Rupt.
			29,700)*	27,682	2,048	7.40	

TABLE II

RUPTURING PRESSURE OF PRIMER TUBES
WITH VARIOUS VENT HOLE DIAMETERS AND UNVENTED LENGTHS

Vent Hole Diameter	Unvented Length	Rupturing Pressure psi	**Average Rupturing Pressure psi**	Standard Deviation psi	Coefficient of Variation
3/32	2	19,600 21,900)* 18,400) 17,700)* 18,700) 19,100)* 21,800) 17,700)* 16,700)	19,067	1,792	9.40
3/32	5	19,700 19,000)* 20,100) 22,500)* 24,500)	21,160	2,284	10.8
3/32	7	24,200)* 25,000) 29,400 34,500 34,500	29,520	4,957	16.8
3/32	9	25,600)* 25,500) 32,300 30,200)* 27,500) 33,000	29,016	2,831	9.76
5/32	2	22,700)* 24,900) 25,900)* 24,000) 24,700)* 23,800) 22,900	24,128	1,135	4.70

* Indicates that two pressure measurements were simultaneously recorded.

TABLE II (continued)

Vent Hole Diameter	Unvented Length	Rupturing Pressure psi	Average Rupturing Pressure psi	Standard Deviation psi	Coefficient of Variation
5/32	5	27,500)* 29,700) 24,400)* 22,200) 32,800)* 30,800)	27,900	4,014	14.4
5/32	7	32,500)* 31,200) 32,400)* 27,700) 28,800)* 28,000)	30,100	2,196	9.30
5/32	9	28,400)* 27,400) 25,400)* 26,200) 34,900)* 34,500) 32,300 34,200)* 33,000)	30,700	3,810	12.40
7/32	2	30,600 27,700)* 26,800) 24,100)* 28,500) 29,300)* 29,700)	28,100	2,170	7.72
7/32	5	26,500 26,700 27,000)* 26,700) 31,500)* 30,700)	28,183	2,293	8.14

TABLE II (continued)

Vent Hole Diameter	Unvented Length	Rupturing Pressure psi	**Average Rupturing Pressure psi**	Standard Deviation psi	Coefficient of Variation
7/32	7	31,000 33,700)* 31,000) 32,000)* 31,000) 28,900)* 32,700)	31,471	1,535	4.88
7/32	9	27,600 29,500)* 31,500) 29,700	29,600	1,594	5.39

TABLE III

PEAK PRESSURE AND OTHER DATA ON TUBES WITH VARIOUS WALL THICKNESSES AND CONSTANT INSIDE DIAMETERS

Wall Thickness	Charge	Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
.065	3FG+4%pp** 80 grams	20,000) 19,400) *				
		17,600) 17,300) *				
		15,300) 16,600) *	17,833	1,705	9.56	
.065	3FG+8%pp 76 grams	23,500) 24,200) *				
		27,700) 28,200) *				
		25,700) 25,400) *	25,783	1,865	7.23	
.065	3FG+12%pp 72 grams	26,900) 27,900) *				Rupt.
		24,900) 24,300) *				Rupt.
		27,200) 25,800) *	26,167	1,367	5.22	Rupt.
.095	3FG+12%pp 72 grams	28,300) 28,200) *				
		27,000) 30,000) *				
		27,300) 26,980) *	27,963	1,153	4.12	

* Indicates that two pressure measurements were simultaneously recorded.

** Pistol powder - SR4990

TABLE III (continued)

Wall Thickness	Charge	Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
.095	3FG+16%pp 69 grams	31,500)* 32,200) 31,000)* 30,000) 25,200)* 25,400)	29,217	3,118	10.7	Rupt.
.095	3FG+20%pp 66 grams	30,000)* 32,500) 29,700 28,200)* 27,100)	29,500	2,046	6.93	Rupt. Rupt. Rupt.
.120	3FG+16%pp 69 grams	25,000)* 25,300) 29,500)* 28,500) 31,400)* 32,200)	28,650	3,015	10.5	Rupt.
.120	3FG+20%pp 66 grams	29,200)* 32,000) 26,700)* 29,800) 29,000)* 27,400)	29,017	1,872	6.45	Rupt.
.120	3FG+24%pp 64 grams	34,700 34,800 34,700	34,733	58	.17	Rupt. Rupt.

TABLE III (continued)

Wall Thick-ness	Charge	Pressure psi	Average Peak Pres-sure psi	Standard Deviation psi	Coefficient of Variation	Remarks
.156	3FG+16%pp	30,000)*				
	69 grams	28,600)				
		32,600				
		31,400)*				
		33,400)	31,200	1,939	6.21	
.156	3FG+20%pp	39,900				Bulge
	66 grams	36,400				
		35,800				Bulge
		35,600				
		46,800				Rupt.
		32,300				Rupt.
		37,700	37,643	4,593	12.2	Bulge
.156	3FG+24%pp	37,800				Bulge
	64 grams	53,000				Rupt.
		47,400				Bulge
		37,300)*				Rupt.
		42,300)				
		39,200				Rupt.
		35,100	41,729	6,389	15.3	
.156	3FG+28%pp	50,100				Rupt.
	62 grams	38,200				
		40,800				Rupt.
		50,800				Bulge
		43,000				Rupt.
		38,500	43,566	5,612	12.9	

TABLE IV

RUPTURING PRESSURES OF PRIMER TUBES WITH VARIOUS WALL THICKNESSES AND CONSTANT INSIDE DIAMETER

Wall Thickness	Rupturing Pressure psi	Average Rupturing Pressure psi	Standard Deviation psi	Coefficient of Variation
.065	26,900)* 27,900) 24,900)* 24,300) 27,200)* 25,800)	26,167	1,367	5.22
.095	25,200)* 25,400) 30,000)* 32,500) 29,700 28,200)* 27,100)	28,300	2,644	9.34
.120	31,400)* 32,200) 26,700)* 29,800) 34,800 34,700	31,600	3,082	9.75
.156	46,800 32,300 53,000 37,300)* 42,300) 39,200 50,100 40,800 43,000	42,755	6,875	16.1

* Indicates that two pressure measurements were simultaneously recorded.

TABLE V

PEAK PRESSURES AND OTHER DATA ON TUBES WITH VARIOUS INSIDE DIAMETERS AND CONSTANT WALL THICKNESS

Inside Diameter of Tube	Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
.435	Cannon 44 grams	12,900)* 13,200) 10,300)* 10,600) 13,800)* 14,600)	12,567	1,743	13.9	
.435	3FG+8%pp** 42 grams	22,000)* 23,900) 22,300)* 20,000) 22,200)* 22,600)	22,167	1,312	5.91	
.435	3FG+12%pp 40 grams	24,100)* 25,800) 27,300)* 26,000) 26,000)* 25,900)	25,850	932	3.60	
.435	3FG+16%pp 38 grams	29,900)* 30,700) 26,800)* 26,300) 26,800)* 25,800)	27,717	2,051	7.40	

* Indicates that two pressure measurements were simultaneously recorded.

** Pistol Powder - SR4990.

TABLE V (continued)

Inside Diameter of Tube	Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coefficient of Variation	Remarks
.435	3FG+20%pp 36 grams	28,300 35,000) 34,300) * 25,500) 28,200) *	30,260	1,319	4.36	
.435	3FG+24%pp 34 grams	32,000) 32,700) * 31,400) 28,200) * 30,400	30,900	1,676	5.42	Rupt. Rupt.
.435	3FG+28%pp 32 grams	36,500) 36,100) * 30,200 35,400	34,553	2,935	7.92	Rupt. Bulge Rupt.
.685	Cannon 122 grams	10,500) 10,000) * 10,000) 9,300) * 10,400	10,040	472	4.70	
.685	3FG+8%pp 107 grams	20,900) 20,000) * 23,700) 23,600) * 19,800) 19,700) *	21,284	1,964	9.23	
.685	3FG+12%pp 102 grams	24,200) 23,600) * 21,500) 22,900) * 22,800) 20,900) *	22,650	1,247	5.50	

TABLE V (continued)

Inside Diameter of Tube	Charge	Peak Pressure psi	Average Peak Pressure psi	Standard Deviation psi	Coeffi of Varia
.685	3FG+16%pp 97 grams	31,000)* 28,900) 29,000)* 27,500) 28,300	28,940	1,547	5.
.685	3FG+20%pp 92 grams	28,700)* 28,900) 27,200)* 25,600) 31,000)* 31,000)	28,733	2,082	7.
.810	Cannon 170 grams	11,000)* 9,900) 9,800)* 9,500) 11,500)* 9,600)	10,217	1,194	11.
.810	3FG+4% 156 grams	19,800)* 19,200) 22,800)* 22,700) 17,500)* 17,200)	19,866	2,441	12.
.810	3FG+8% 149 grams	21,600 18,400)* 19,400) 25,300)* 24,200)	21,780	2,974	13.
.810	3FG+12%pp 142 grams	21,500)* 21,500) 23,900)* 22,700) 18,800)* 20,100)	21,416	1,812	8.4

TABLE VI

RUPTURING PRESSURES OF PRIMER TUBES WITH VARIOUS INSIDE DIAMETERS AND CONSTANT WALL THICKNESS

Inside Diameter of Tubes	Rupturing Pressure psi	Average Rupturing Pressure psi	Standard Deviation psi	Coefficient of Variation
.435	31,400)* 28,200) 30,400 36,500)* 36,100) 35,400	33,000	3,465	10.5
.685	29,000)* 27,500) 28,300 28,700)* 28,900) 31,000)* 31,000)	29,200	1,328	4.55
.810	21,500)* 21,500) 23,900)* 22,700) 18,800)* 20,100)	21,416	1,812	8.46

* Indicates that two pressure measurements were simultaneously recorded.

TABLE VII

PEAK PRESSURES FOR TUBES WITH VARIOUS UNVENTED LENGTHS AND VARIOUS AMOUNTS OF PRIMER CHARGE

Tube	Unvented Length	Primer Charge	Peak Pressure psi	Average Peak Pressure psi
Mk 39	3.75	Cannon 43.5 grams	9,900) * 9,200) 11,000) * 11,800) 10,700 10,200 11,500) * 11,000) 8,500) * 10,000)	10,380
Mk 39	3.75	Cannon 87 grams	10,600) * 10,400) 11,100 11,500) * 11,400) 9,300 10,900) * 10,900) 11,600) * 11,400)	10,910
XCM11	6.75	Cannon 26 grams	8,400) * 7,800) 10,700) * 10,200) 11,700) * 10,900) 9,300) * 8,500)	9,687

* Indicates that two pressure measurements were simultaneously recorded.

TABLE VII (continued)

Tube	Unvented Length	Primer Charge	Peak Pressure psi	Average Peak Pressure psi
XCM11	6.75	Cannon 42 grams	13,500)* 13,300)	13,400
XCM11	6.75	Cannon 70 grams	16,100)* 15,500)	15,800
XCM11	3.75	Cannon 26 grams	10,500)* 10,700) 9,900 10,500 9,300)* 8,300)	9,867
XCM11	3.75	Cannon 70 grams	10,500)* 11,500)	11,000
XCM11	9.75	Cannon 26 grams	9,900)* 10,000)	9,950
XCM11	9.75	Cannon 70 grams	24,900)* 24,500)	24,700

TABLE VIII

CHANGES IN PEAK PRESSURE ALONG THE PRIMER TUBE

Shot Number	Gauge Position (inches from stock)	Peak Pressure psi	Remarks
1	2.5 6	17,500 24,000	With paper plug
2	2.5 10.5	17,600 21,200	
3	2.5 15	16,400 18,000	
4	2.5 19.5	19,200 14,900	
5	2.5 6	19,200 20,200	With steel plug
6	2.5 10.5	17,200 24,400	
7	2.5 15	17,400 19,700	
8	2.5 19.5	17,200 16,400	

TABLE IX

RUPTURING PRESSURE FOR TUBES WITH SLOT-LIKE VENT HOLES, ROUND VENT HOLES AND NO VENT HOLES

Vent Holes	Primer Charge	Pressure psi	Average Rupturing Pressure psi	Remarks
Slotted	3FG+20%pp**	20,400		Rupt.*
	3FG+16%pp	25,000		
	3FG+20%pp	26,900		Rupt.
	3FG+20%pp	26,700		Rupt.
			24,666	
Round	3FG+20%pp	31,000		Rupt.
	3FG+16%pp	22,800		
	3FG+20%pp	27,900		
	3FG+24%pp	31,700		Rupt.
	3FG+20%pp	24,400		
	3FG+24%pp	28,900		Rupt.
			30,533	
None	3FG	28,800		
	3FG+8%pp	30,400		Rupt.
	3FG	29,000		
	3FG+8%pp	33,000		Rupt.
	3FG+8%pp	27,300		Rupt.
			30,233	

* Tube bent at 35° angle at first vent hole.

** Pistol Powder - SR4990.

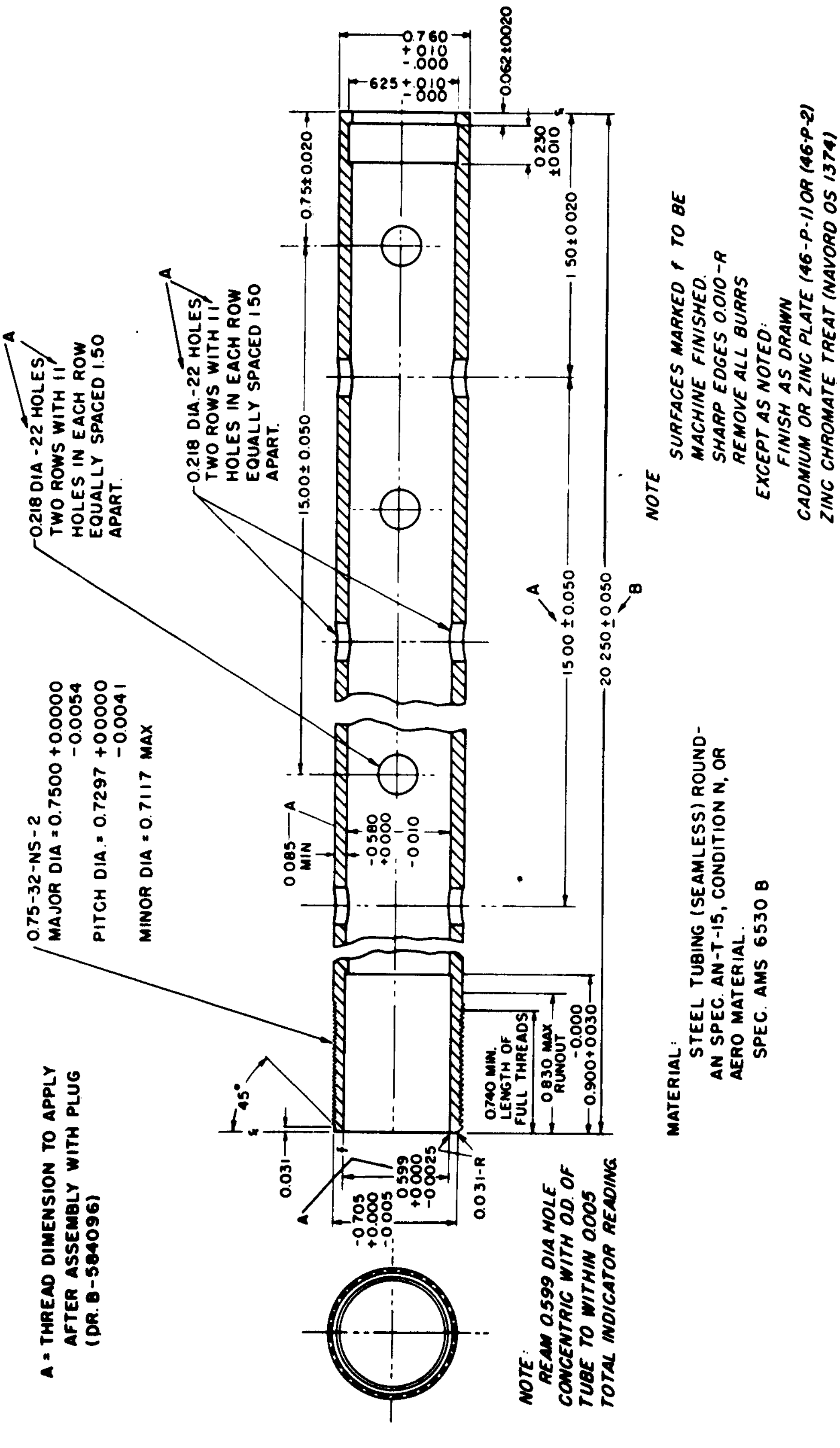
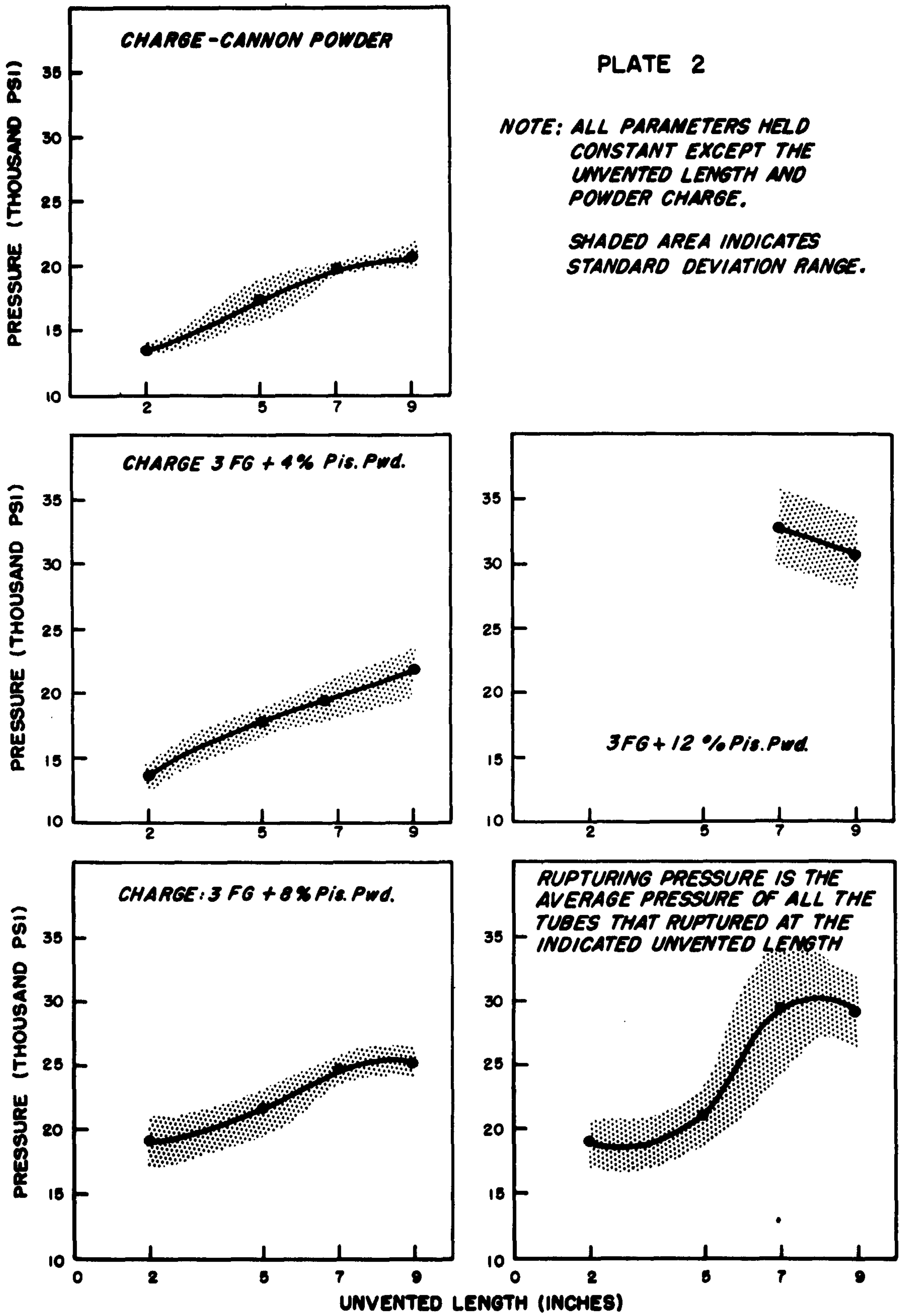
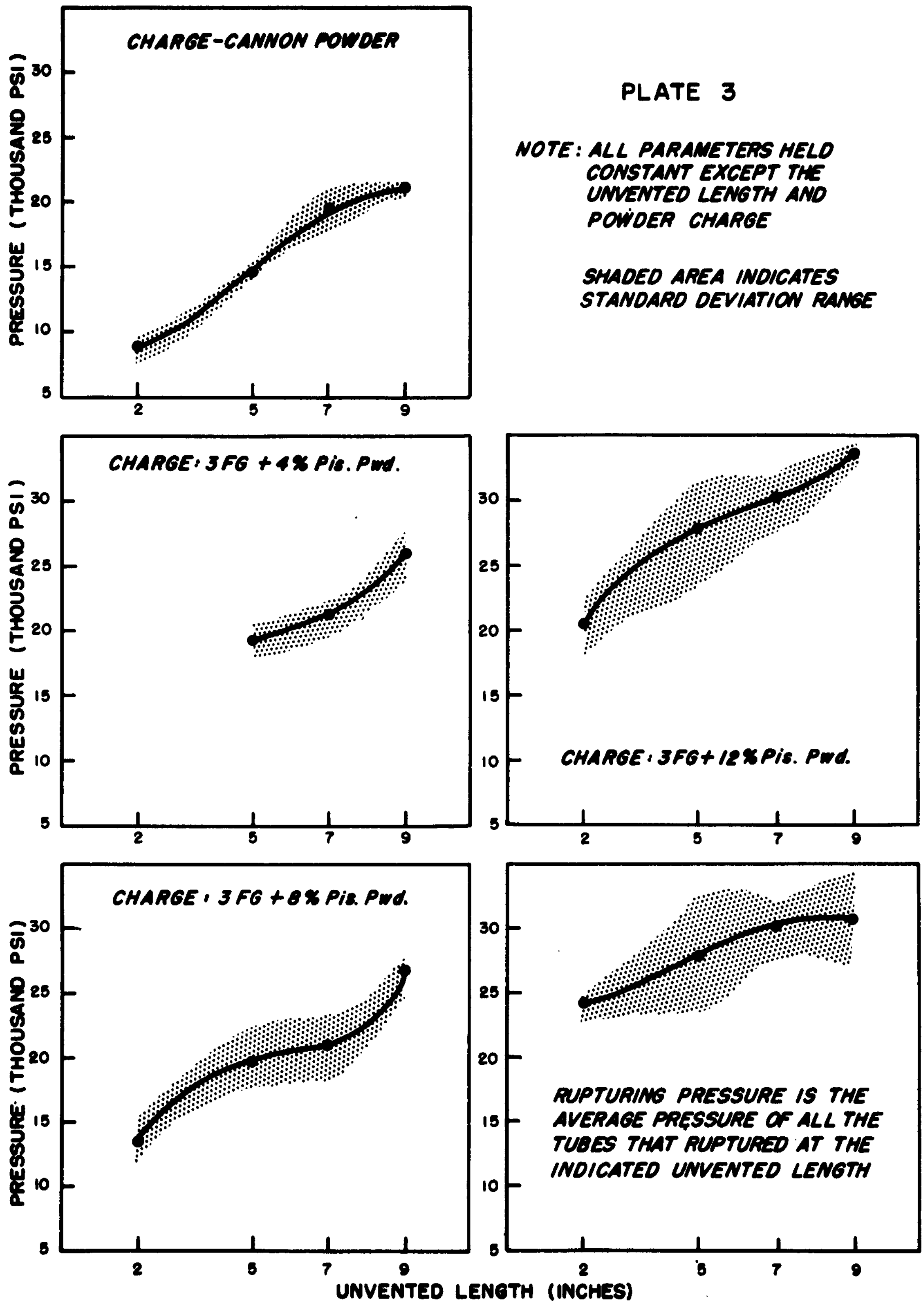


PLATE I
MK 39 PRIMER TUBE
(FROM B-584095)

PLATE 2

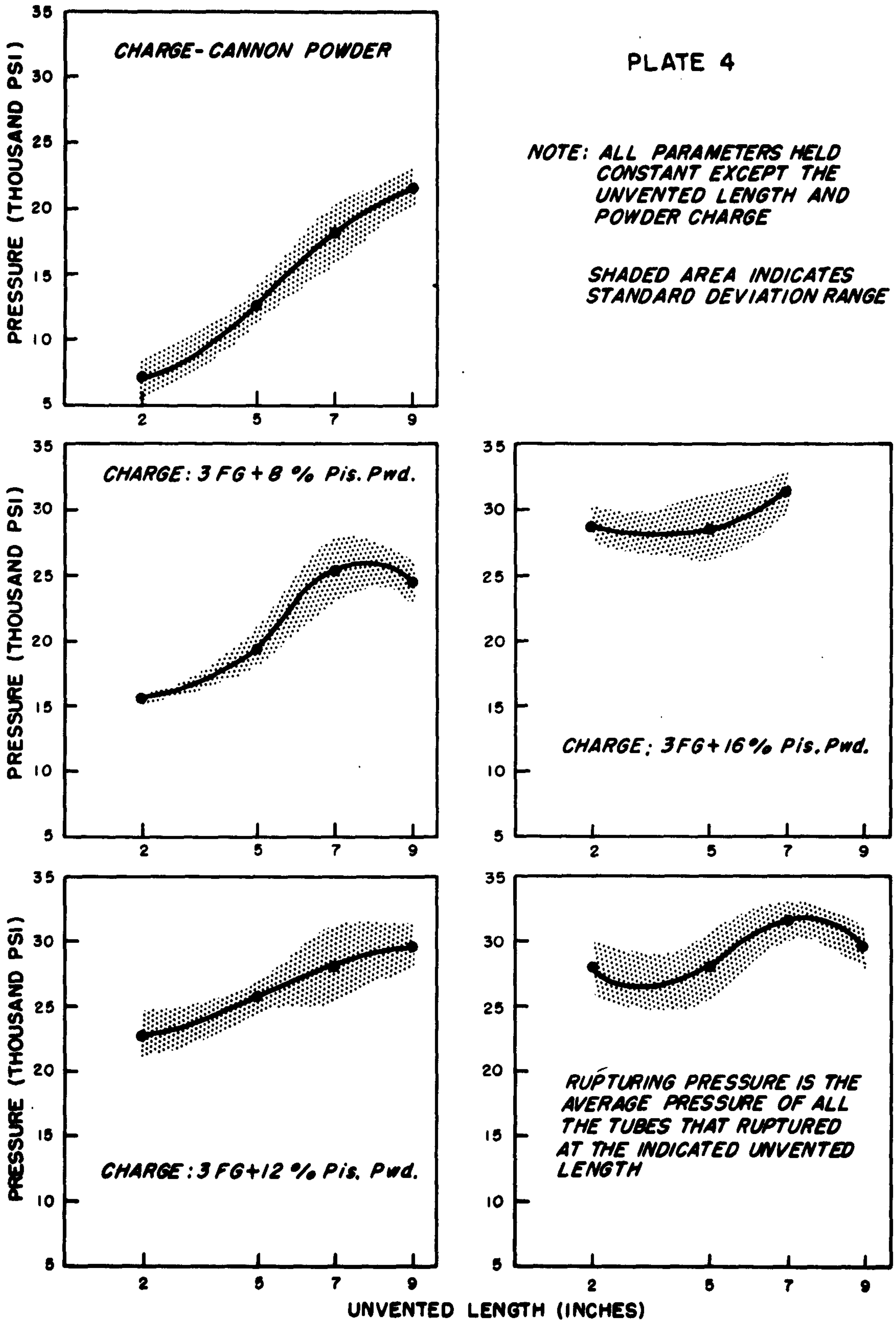


AVERAGE PEAK PRESSURE AND RUPTURING PRESSURE FOR TUBES WITH 3/32 OF AN INCH VENT HOLES

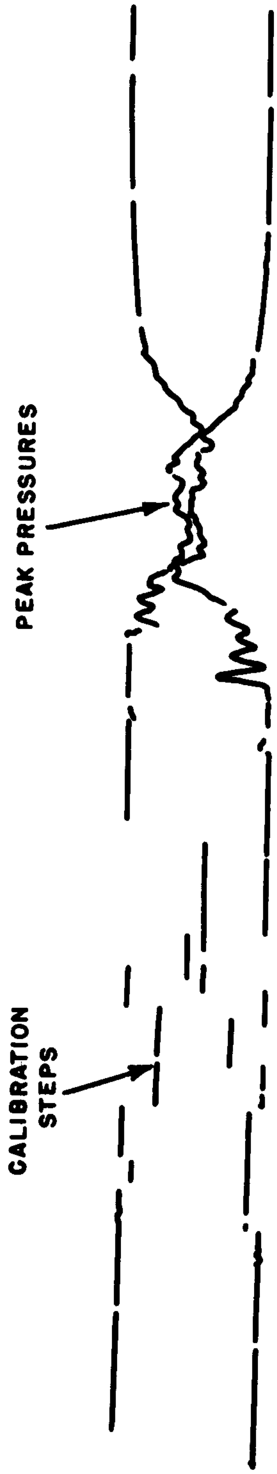


AVERAGE PEAK PRESSURE AND RUPTURING PRESSURE FOR TUBES WITH 5/32 OF AN INCH VENT HOLES

PLATE 4



AVERAGE PEAK PRESSURE AND RUPTURING PRESSURE FOR TUBES WITH 7/32 OF AN INCH VENT HOLES



PRESSURE-TIME CURVES FOR TUBE WITH 3/32 OF AN INCH DIAMETER VENT HOLES AND 2 INCHES OF UNVENTED LENGTH. TUBE RUPTURED. PRESSURES RECORDED 17,700 AND 16,700 PSI

PRESSURE-TIME CURVES FOR TUBE WITH 7/32 OF AN INCH DIAMETER VENT HOLES AND 2 INCHES OF UNVENTED LENGTH. TUBE RUPTURED. PRESSURES RECORDED 29,300 AND 29,700 PSI

PLATE 5

PRESSURE-TIME CURVES SHOWING PEAK PRESSURE DURATION

PLATE 6
AVERAGE RUPTURING PRESSURE
VS
WALL THICKNESS OF TUBE

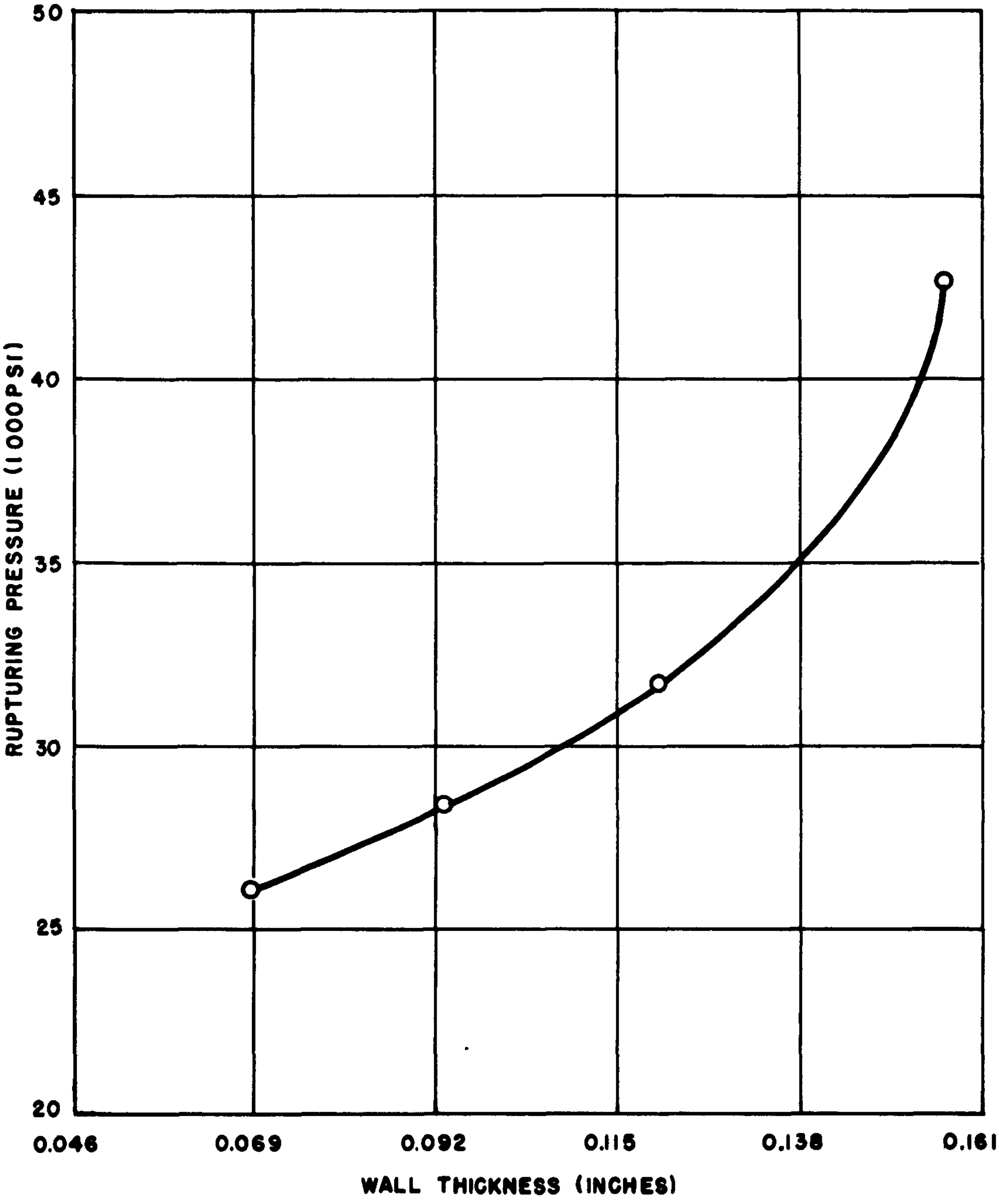


PLATE 7
AVERAGE RUPTURING PRESSURE
VS
INSIDE DIAMETER OF TUBE

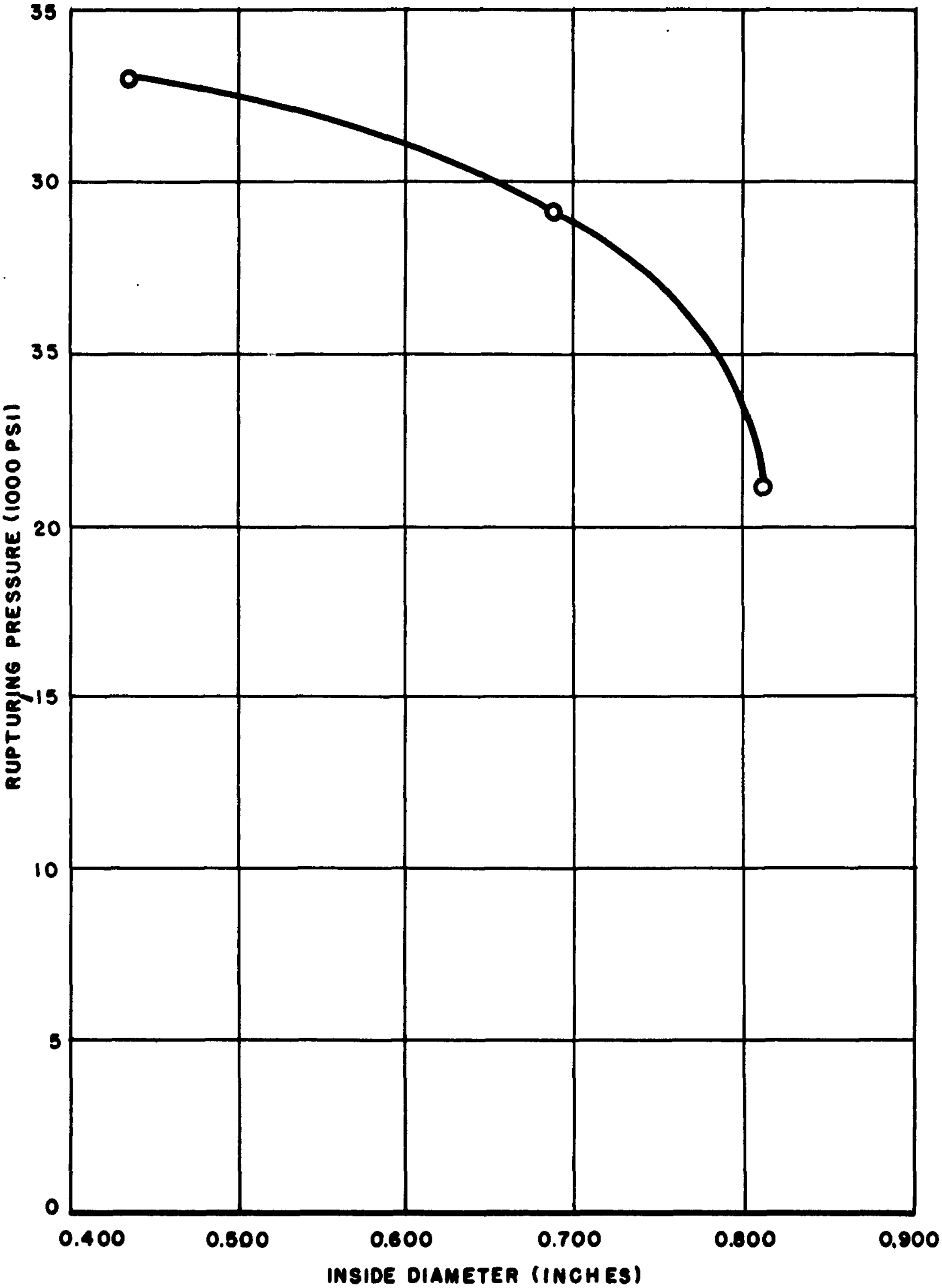
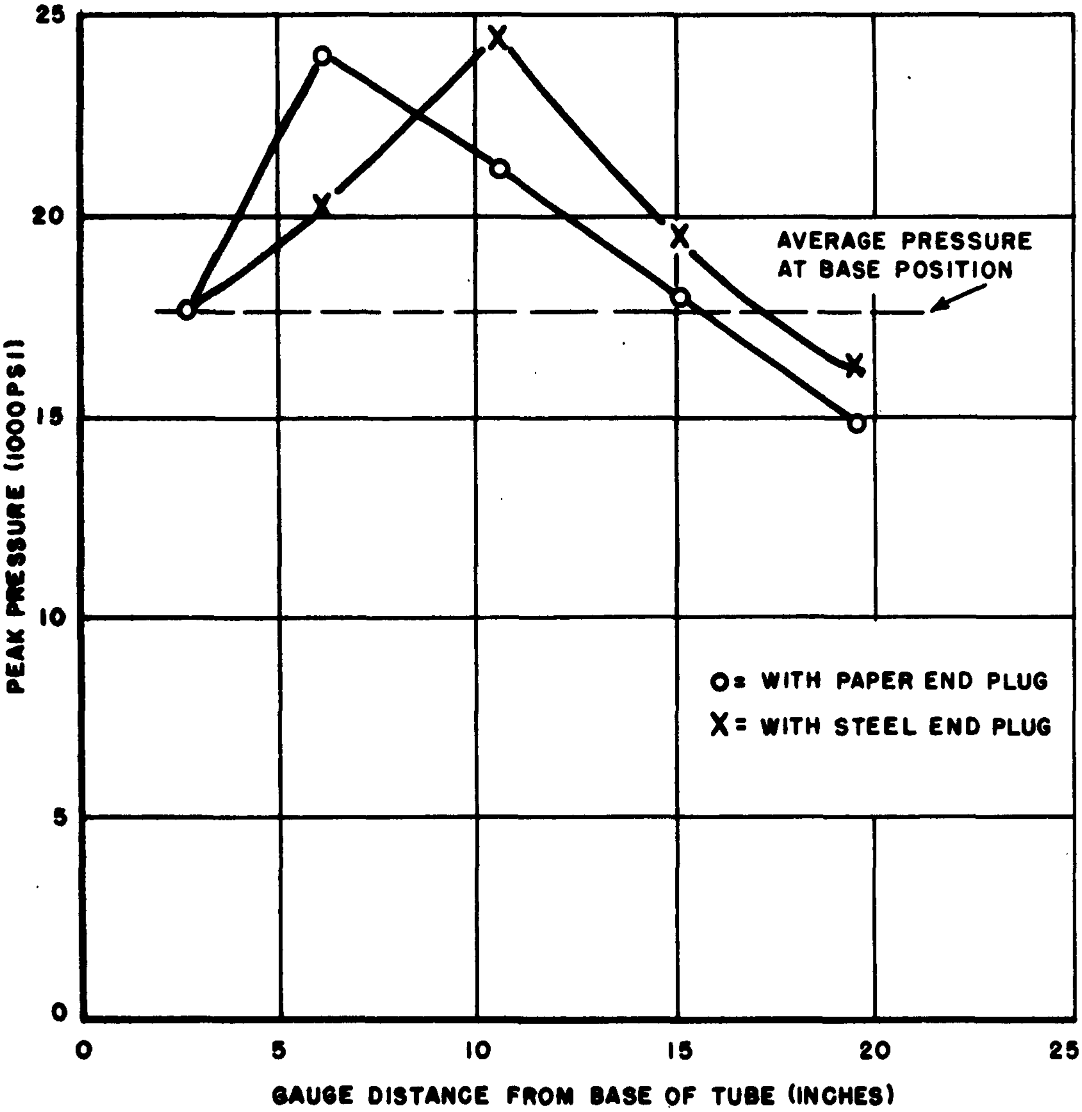
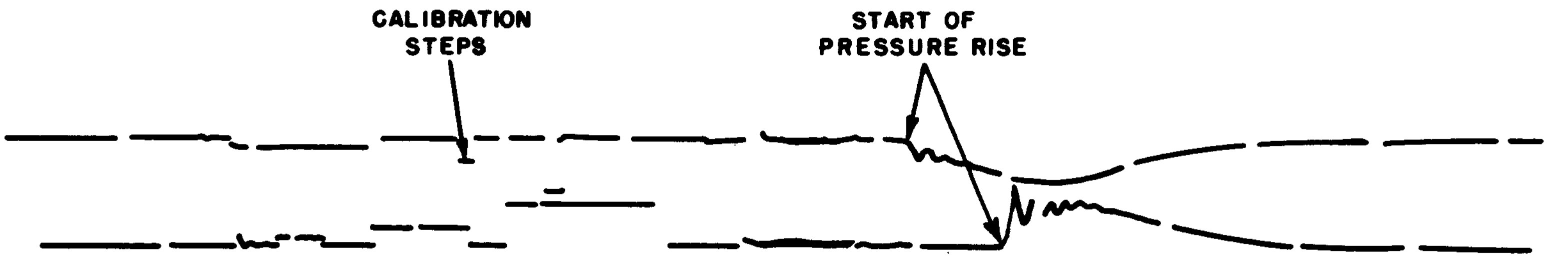


PLATE 8
HEAVY-WALLED PRIMER TUBE

PLATE 9
PEAK PRESSURE VARIATION IN PRIMER TUBE





TOP CURVE = PRESSURE RECORDED AT BASE OF TUBE- 17,500 PSI

BOTTOM CURVE = PRESSURE RECORDED AT POSITION 6 INCH ABOVE THE STOCK 24,000 PSI

PLATE 10
PRESSURE-TIME CURVE ILLUSTRATING RATE OF PRESSURE RISE IN PRIMER TUBE